

Three-Body Decays of SUSY Particles

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Abstract

We analyze the decays of charginos, neutralinos, gluinos and the first/second generation squarks in the Minimal Supersymmetric extension of the Standard Model, focusing on the three-body decays in scenarios where the ratio $\tan\beta$ of vacuum expectation values of the two Higgs doublet fields is large. We show that the three-body decays of the next-to-lightest neutralinos (lightest charginos) into $b\bar{b}, \tau^+\tau^-$ ($\tau\nu$) final states, where third generation sfermion and Higgs boson exchange diagrams play an important role, are dominant. Furthermore, we show that decays of gluinos into $b\bar{b}$ final states and squark decays into lighter sbottoms through gluino exchange can also have sizeable branching fractions, especially in scenarios where the soft SUSY breaking gaugino mass parameters are not unified at the GUT scale.

1. Introduction

Supersymmetric theories (SUSY) [1] are the best motivated extensions of the Standard Model (SM) of the strong and electroweak interactions and the search for supersymmetric particles is one of the major goals of present and future collider experiments. The Minimal Supersymmetric extension of the Standard Model (MSSM), with R-parity conservation [leading to a stable lightest SUSY particle (LSP) which is in general the lightest neutralino χ_1^0], the minimal particle content [three generations of fermions, two Higgs doublet fields to break the electroweak symmetry, as well as their SUSY partners] and a set of soft terms to break SUSY [e.g. mass terms for gauginos, sfermions and Higgs bosons, and trilinear couplings between squarks and Higgs bosons], is the most studied in the literature [1].

In the MSSM, the phenomenology of the third generation sfermions is rather special. Indeed, due to the large value of the top, bottom and tau lepton masses, the two current eigenstates \tilde{f}_L and \tilde{f}_R (with $\tilde{f} = \tilde{t}, \tilde{b}$ or $\tilde{\tau}$) could strongly mix [2], leading to a large splitting between the two mass eigenstates \tilde{f}_1 and \tilde{f}_2 with the lighter one, \tilde{f}_1 , possibly much lighter than the other sfermions. In particular, for large values of the parameter $\tan\beta$, the ratio of the vacuum expectation values of the two Higgs fields¹, and non-zero values of the Higgs–higgsino mass parameter μ , the mixing can be extremely strong in the sbottom and stau sectors, leading to relatively light \tilde{b}_1 and $\tilde{\tau}_1$ states². [In turn, for large values of the trilinear coupling A_t and/or small $\tan\beta$ values, the mixing can be strong in the stop sector, leading to a \tilde{t}_1 eigenstate much lighter than the other squarks and possibly lighter than the top quark itself.]

A light \tilde{b}_1 [and/or $\tilde{\tau}_1$] eigenstate may lead to dramatic consequences on the decay modes of the next-to-lightest neutralino, the lightest chargino, the gluino as well as the first and second generation squarks. Indeed, in this case, one has the following scenarii:

(i) The possibility that squarks of the first and second generations decay into the lighter \tilde{b}_1 squark through the mode

$$\tilde{q}_{L,R} \rightarrow q \tilde{g}^* \rightarrow q b \tilde{b}_1^* + q \bar{b} \tilde{b}_1 \quad (1)$$

opens up. Because it is a QCD mediated decay, and because the decays into light charginos and neutralinos could be suppressed [e.g., if these particles are higgsino-like since the couplings are proportional to the light quark mass in this case], this mode might have a sizeable branching fraction, in particular in models where the gaugino masses are not unified at the GUT scale.

(ii) If gluinos are lighter than squarks, they will mainly decay through virtual squark exchange into quarks and charginos/neutralinos; if \tilde{b}_1 is the lightest squark, its virtuality will be smaller, leading to the possible dominance of the decay mode

$$\tilde{g} \rightarrow b \tilde{b}^*, \bar{b} \tilde{b} \rightarrow b \bar{b} \chi_j^0 \text{ and/or } b t \chi_j^\pm \quad (2)$$

¹Note that large values of the parameter $\tan\beta$, $\tan\beta \sim 50$, are favored in models with unification of the Yukawa couplings; see e.g. Ref. [3]. [The other solution, with $\tan\beta \sim 1.5$, seems to be excluded from the negative searches [4] of MSSM Higgs bosons at LEP2].

²Lighter third generation sfermions have been also advocated in many models such as those with inverted mass hierarchy where the first and second generation squarks are much heavier than their third generation partners; for recent papers see e.g. Ref. [5].

(iii) The lightest chargino χ_1^+ and the next-to-lightest neutralino χ_2^0 will decay into the LSP and two light fermions. This occurs through gauge boson, Higgs boson and sfermion exchange diagrams. Because for high $\tan\beta$ values, the third generation sfermions, sbottoms and staus, are lighter and the Higgs bosons couple strongly to bottom quarks and tau leptons, the three-body decays:

$$\chi_2^0 \rightarrow \chi_1^0 \bar{b} b, \chi_1^0 \tau^+ \tau^- \quad (3)$$

$$\chi_1^+ \rightarrow \chi_1^0 \tau^+ \nu \quad (4)$$

are in general enhanced compared to decays where first and second generation fermions are involved in the final states. For large values of $\tan\beta$, these three-body decay modes have been discussed in Ref. [6] and partly in Ref. [7] in the case of the neutralino χ_2^0 .

In this note, we analyze these various decay modes and investigate their consequences. In the next section we discuss the three body decays of squarks and gluinos, after presenting the analytical expressions for the partial widths. In Section 3, we analyze the three-body decays of the lightest chargino χ_1^+ and the second lightest neutralino χ_2^0 ; we give some illustrations on the branching ratios of these decay modes and compare our results with those of Ref. [6]. Some conclusions are then given in section 4.

2. Three-body decays of squarks and gluinos

The Feynman diagrams for the three-body decays of squarks of the first and second generations into the lighter \tilde{b}_1 squark, eq.(1), and of gluinos through sbottom exchange, eq.(2), are given in Fig. 1.

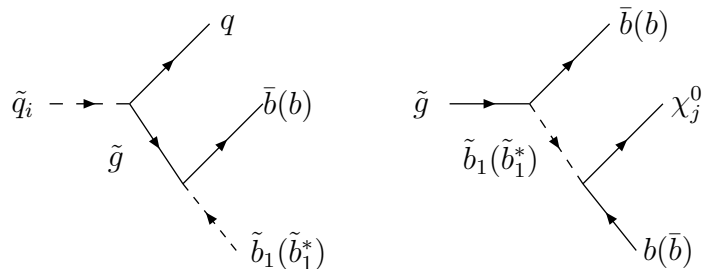


Figure: Generic Feynman diagrams for the three-body decays of squarks and gluinos.

The Dalitz plot density of the decay mode eq. (1) is given in terms of the reduced energies of the two final state quarks, $x_1 = 2E_q/m_{\tilde{q}_i}$ and $x_2 = 2E_b/m_{\tilde{q}_i}$, and the gluino and sbottom reduced squared masses, $\mu_{\tilde{g}} = m_{\tilde{g}}^2/m_{\tilde{q}_i}^2$ and $\mu_{\tilde{b}} = m_{\tilde{b}}^2/m_{\tilde{q}_i}^2$. Neglecting the masses of the final state quarks³, and adding incoherently the contribution from the two different $\tilde{b}\tilde{b}_1$ and $b\tilde{b}_1^*$ final states, it is given by:

$$\begin{aligned} \frac{d\Gamma(\tilde{q}_i)}{dx_1 dx_2} &= \frac{\alpha_s^2}{3\pi} m_{\tilde{q}_i} \frac{1}{(1-x_1-\mu_{\tilde{g}})^2} \left[a_i^2 [(1-x_1+\mu_{\tilde{b}})(1-x_2+\mu_{\tilde{b}}) \right. \\ &\quad \left. + \mu_{\tilde{b}}(1-x_1-x_2-\mu_{\tilde{b}})] - b_i^2 \mu_{\tilde{g}}(1-x_1-x_2-\mu_{\tilde{b}}) \right] \end{aligned} \quad (5)$$

³The expressions with the mass effects in this case and for gluino decays to be discussed later [with the additional final states $\tilde{g} \rightarrow b\chi_j^\pm$ etc..] are slightly more involved and will be given elsewhere [8].

where the factors a_i and b_i for the squark \tilde{q}_i are given, in terms of the \tilde{b} mixing angle θ_b , by:

$$a_1 = b_2 = \sin \theta_b \quad \text{and} \quad a_2 = b_1 = \cos \theta_b \quad (6)$$

Integrating over the energies x_1, x_2 with boundary conditions

$$0 \leq x_1 \leq 1 - \mu_{\tilde{b}} \quad \text{and} \quad 1 - x_1 - \mu_{\tilde{b}} \leq x_2 \leq 1 - \mu_{\tilde{b}}/(1 - x_1) \quad (7)$$

one obtains the partial decay width:

$$\begin{aligned} \Gamma(\tilde{q}_i) = & \frac{\alpha_s^2}{3\pi} m_{\tilde{q}_i} \left\{ a_i^2 \left[\frac{(1 - \mu_{\tilde{g}})(\mu_{\tilde{b}} - \mu_{\tilde{g}})}{2\mu_{\tilde{g}}^2} (\mu_{\tilde{g}} - 3\mu_{\tilde{g}}^2 + \mu_{\tilde{b}} + \mu_{\tilde{g}}\mu_{\tilde{b}}) \text{Log} \frac{\mu_{\tilde{g}} - \mu_{\tilde{b}}}{\mu_{\tilde{g}} - 1} \right. \right. \\ & - \frac{\mu_{\tilde{b}}^2}{2\mu_{\tilde{g}}^2} \text{Log} \mu_{\tilde{b}} + \frac{\mu_{\tilde{b}} - 1}{4\mu_{\tilde{g}}} (5\mu_{\tilde{g}} - 6\mu_{\tilde{g}}^2 - 2\mu_{\tilde{b}} + 5\mu_{\tilde{g}}\mu_{\tilde{b}}) \left. \right] \\ & + b_i^2 \left[\frac{(1 - \mu_{\tilde{g}})(\mu_{\tilde{b}} - \mu_{\tilde{g}})}{\mu_{\tilde{g}}^2} (\mu_{\tilde{b}} - \mu_{\tilde{g}}^2) \text{Log} \frac{\mu_{\tilde{g}} - \mu_{\tilde{b}}}{\mu_{\tilde{g}} - 1} \right. \\ & \left. \left. + \frac{\mu_{\tilde{b}}}{\mu_{\tilde{g}}^2} (\mu_{\tilde{g}} - \mu_{\tilde{b}} + \mu_{\tilde{g}}\mu_{\tilde{b}}) \text{Log} \mu_{\tilde{b}} + \frac{\mu_{\tilde{b}} - 1}{2\mu_{\tilde{g}}} (\mu_{\tilde{g}} - 2\mu_{\tilde{g}}^2 - 2\mu_{\tilde{b}} + \mu_{\tilde{g}}\mu_{\tilde{b}}) \right] \right\} \quad (8) \end{aligned}$$

Neglecting again the mass of the final bottom quark [but not in the couplings], the Dalitz plot density for the gluino decay $\tilde{g} \rightarrow b\bar{b}\chi_1^0$ through $\tilde{b}_i = \tilde{b}_1, \tilde{b}_2$ exchange is simply given by [here, $x_1 = 2E_b/m_{\tilde{g}}, x_2 = 2E_{\bar{b}}/m_{\tilde{g}}$ and $\mu_{\tilde{b}_i} = m_{\tilde{b}_i}^2/m_{\tilde{g}}^2, \mu_\chi = m_{\chi_1^0}^2/m_{\tilde{g}}^2$]

$$\frac{d\Gamma(\tilde{g})}{dx_1 dx_2} = \frac{\alpha_s \alpha}{4\pi} m_{\tilde{g}} \sum_i (a_{ji}^2 + b_{ji}^2) \frac{x_1 (1 - \mu_\chi - x_1)}{(1 - x_1 - \mu_{\tilde{b}_i})^2} \quad (9)$$

and after integration on the variables x_1 and x_2 , one obtains for the partial width:

$$\begin{aligned} \Gamma(\tilde{g}) = & \frac{\alpha_s \alpha}{4\pi} m_{\tilde{g}} \sum_i \frac{(a_{ji}^2 + b_{ji}^2)}{\mu_{\tilde{b}_i}^2} \left\{ \frac{1}{2} \mu_{\tilde{b}_i} (\mu_\chi - 1) (5\mu_{\tilde{b}_i} - 6\mu_{\tilde{b}_i}^2 - 2\mu_\chi + 5\mu_{\tilde{b}_i} \mu_\chi) \right. \\ & \left. + (\mu_{\tilde{b}_i} - 1) (\mu_\chi - \mu_{\tilde{b}_i}) (\mu_\chi - 3\mu_{\tilde{b}_i}^2 + \mu_{\tilde{b}_i} + \mu_{\tilde{b}_i} \mu_\chi) \text{Log} \frac{1 - \mu_{\tilde{b}_i}}{\mu_\chi - \mu_{\tilde{b}_i}} - \mu_\chi^2 \text{Log} \mu_\chi \right\} \quad (10) \end{aligned}$$

where the couplings between neutralino χ_j^0 , bottom and sbottoms \tilde{b}_1, \tilde{b}_2 , are given by

$$\begin{aligned} \begin{Bmatrix} a_{j1} \\ a_{j2} \end{Bmatrix} &= \begin{Bmatrix} c_{\theta_b} \\ -s_{\theta_b} \end{Bmatrix} \left[\frac{\sqrt{2}}{3} s_W Z'_{j1} - \frac{\sqrt{2}}{c_W} \left(-\frac{1}{2} + \frac{1}{3} s_W^2 \right) Z'_{j2} \right] - \begin{Bmatrix} s_{\theta_b} \\ c_{\theta_b} \end{Bmatrix} \frac{m_b}{\sqrt{2} M_W \cos \beta} Z_{j3} \\ \begin{Bmatrix} b_{j1}^b \\ b_{j2}^b \end{Bmatrix} &= \begin{Bmatrix} -c_{\theta_b} \\ s_{\theta_b} \end{Bmatrix} \frac{m_b}{\sqrt{2} M_W \cos \beta} Z_{j3} - \begin{Bmatrix} s_{\theta_b} \\ c_{\theta_b} \end{Bmatrix} \frac{\sqrt{2}}{3} s_W (Z'_{j1} - \tan \theta_W Z'_{j2}) \quad (11) \end{aligned}$$

with $s_W^2 = 1 - c_W^2 \equiv \sin^2 \theta_W$ and $s_{\theta_b} \equiv \sin \theta_b$, etc.; the (rotated) matrix elements of the neutralino mass matrix Z'_{ij} are given in Ref. [9]. Note that for massless b quarks, there is no interference between the amplitudes with \tilde{b}_1 and \tilde{b}_2 exchange.

For illustration we analyze the branching ratios in two models, discussed in Ref. [10], where the gaugino masses are not unified at the GUT scale: *i*) Models in which SUSY breaking occurs via an F-term that is not SU(5) singlet but belongs to a representation which appears in the symmetric product of two adjoints: $(\mathbf{24} \otimes \mathbf{24})_{\text{sym}} = \mathbf{1} \oplus \mathbf{24} \oplus \mathbf{75} \oplus \mathbf{200}$ (where only $\mathbf{1}$ leads to universal masses); *ii*) The **OII** model which is superstring motivated and where the SUSY breaking is moduli-dominated. The relative gaugino masses at the GUT scale and at the scale M_Z are given in Tab. 1 taken from Ref. [10].

F_Φ	M_3	M_2	M_1
1	1(~ 6)	1(~ 2)	1(~ 1)
24	2(~ 12)	-3(~ -6)	-1(~ -1)
75	1(~ 6)	3(~ 6)	-5(~ -5)
200	1(~ 6)	2(~ 4)	10(~ 10)
OII	1(~ 6)	5(~ 10)	53/5($\sim 53/5$)

Table 1: Relative gaugino masses at $M_{\text{GUT}}(M_Z)$ in the F_Φ representations and the OII model.

In Fig. 2, we show the branching ratios of the decays $\tilde{q}_1 \rightarrow q b \tilde{b}_1^* + q \tilde{b} \tilde{b}_1$ (2a) and $\tilde{g} \rightarrow \chi^0 b \tilde{b} + \chi^\pm t b$ (2b) as a function of μ and for $\tan \beta = 50$. In Fig. 2a, the (right-handed) squark mass is taken to be $m_{\tilde{q}_1} = 500$ GeV while the gluino mass is slightly larger, $m_{\tilde{g}} \sim M_3 = 550$ GeV. For large values of μ , the lightest neutralinos and chargino are gaugino like, and in models **75** and **OII** have masses comparable to the mass of the gluino [M_1, M_2, M_3 are of the same order in this case; the figure is cut in model **OII** at $\mu \sim M_3$, since the gluino becomes lighter than χ_1^0]: the two-body squark decays into charginos and neutralinos are phase space-suppressed and the virtuality of the gluino is not very large, leading to a rather large $\text{BR}(\tilde{q} \rightarrow q b \tilde{b}_1)$, reaching unity for the extreme values of μ where \tilde{b}_1 is light. In models **1** and **24**, gluinos are much heavier than the lightest charginos and neutralinos [$M_3 \gg M_1$], and the two-body decays $\tilde{q} \rightarrow q \chi$ dominate [but $\text{BR}(\tilde{q}_1 \rightarrow q b \tilde{b}_1^*)$ reaches the level of a few percent]. Model **200** is an intermediate case. For small values of μ , the lightest chargino and neutralinos are higgsino like and much lighter than the gluino, \tilde{b}_1 is also heavier and the two-body decay $\tilde{q} \rightarrow q \chi$ dominate.

In Fig. 2b, the branching ratio $\tilde{g} \rightarrow b \tilde{b} \chi^0 + b t \chi^\pm$ is shown for $M_3 \sim m_{\tilde{g}} = 350$ GeV and a common squark mass $m_{\tilde{q}} = 600$ GeV; with increasing μ the lightest sbottom mass varies from ~ 560 GeV (for $\mu = 200$ GeV) to ~ 357 GeV (for $\mu = 1$ TeV). Even for the universal gaugino mass case, the branching ratio is very large, especially for small and large values of μ . For $\mu \sim 200$ GeV, \tilde{b}_1 is not much lighter than the other squarks, but the $\chi^0 \tilde{b} b$ coupling is enhanced [$\propto m_b/M_W \tan \beta$; see eq. (11)] and the $b \tilde{b}$ final state is favored. For large values of μ , $m_{\tilde{b}_1}$ becomes significantly smaller than $m_{\tilde{q}}$ and the sbottom exchange channel dominates leading to the dominance of $\chi^0 b \tilde{b}$ and $\chi^\pm t b$ final states. As in the case of squark decays, the situation is more favorable for bottom quark decays of the gluino in models **75** and **OII** [in this case also we have cut the plot at $\mu \sim M_3$ since then, $m_{\tilde{g}} < m_{\chi_1^0}$], while it is similar for the **24** and **200** models. For larger μ values, $\mu \geq 1$ TeV, the two-body decay $\tilde{g} \rightarrow b \tilde{b}_1$ is accessible kinematically and will of course dominate [since it is a QCD process] all other channels.

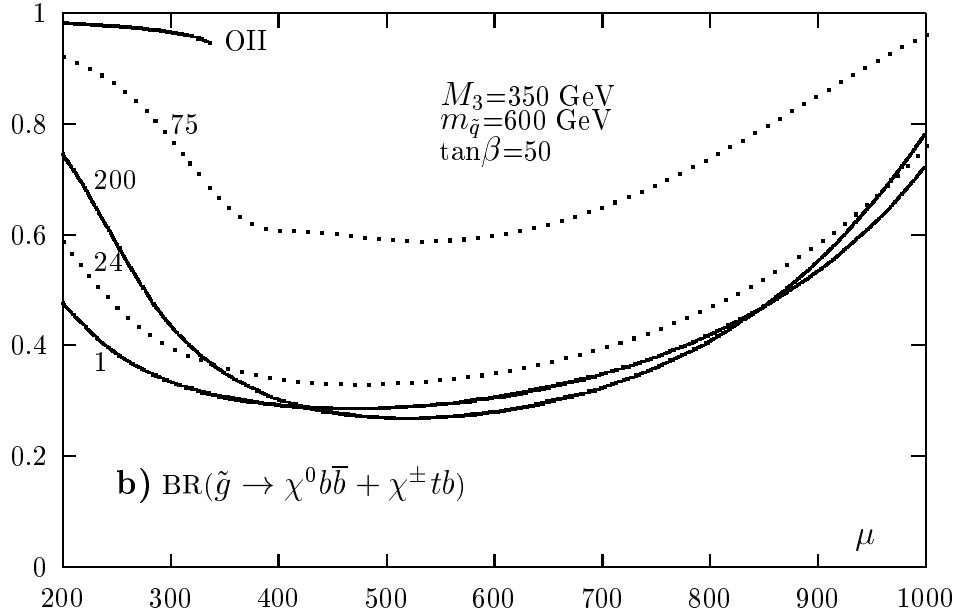
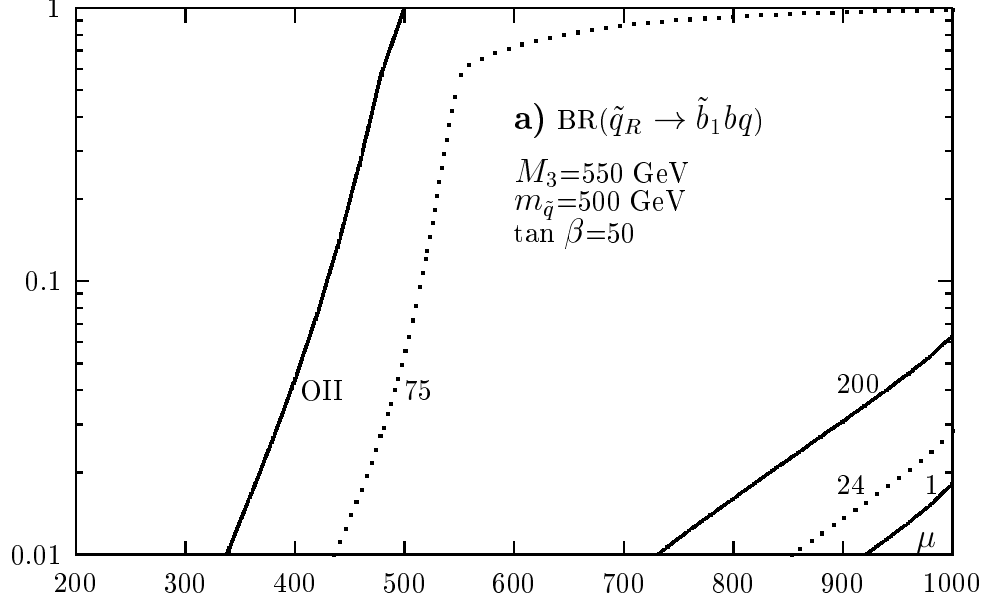


Figure 2: The branching ratios $\text{BR}(\tilde{q}_R \rightarrow q \tilde{b}_1^* + q \tilde{b})$ for a common scalar squark mass $m_{\tilde{q}} = 500 \text{ GeV}$ and $M_3 = 550 \text{ GeV}$ (a) and $\text{BR}(\tilde{g} \rightarrow \chi^0 b \bar{b} + \chi^\pm t b)$ for $m_{\tilde{q}} = 600 \text{ GeV}$ and $M_3 = 350 \text{ GeV}$ (b), as a function of μ for $\tan \beta = 50$ in the various models discussed above. M_3 is fixed and the values of M_1 and M_2 are given Table 1.

3. Chargino and Neutralino Decays

We have also calculated the partial decay widths of the three-body decays of the lightest chargino and of the next-to-lightest neutralino into the LSP and two fermions, eqs. (3–4). These decays are mediated by the exchange of gauge bosons [W boson for χ_1^+ and Z boson for χ_2^0], Higgs bosons [the charged H^+ boson for χ_1^+ and the three neutral Higgs bosons h, H and A for χ_2^0] as well as t and u channel sfermion exchanges [in particular the lighter $\tilde{\tau}_1$ slepton for χ_1^+ and $\tilde{b}_1, \tilde{\tau}_1$ states for χ_2^0 ; Fig. 3].

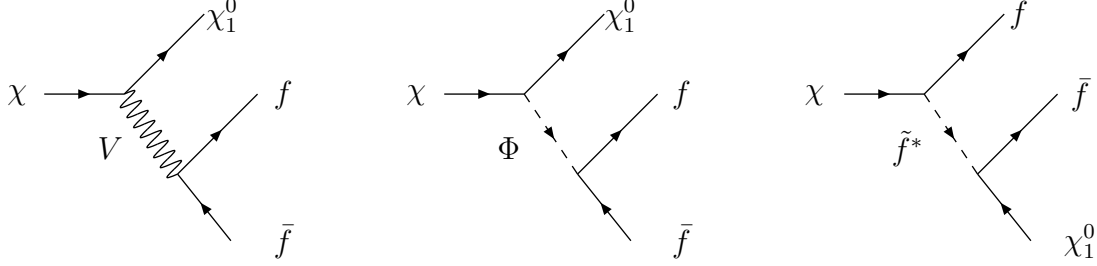


Figure 3: Generic Feynman diagrams contributing to the three-body decays of charginos and neutralinos into the LSP and two fermions.

We have taken into account the contributions of all the channels [and of course the interference terms], the full dependence on the masses of the final fermions [to be able to describe more accurately the cases of chargino decays into $\tau\nu, tb$ and the neutralino decays into $b\bar{b}, t\bar{t}$ final states] and the mixing of the third generation sfermions. Complete analytical formulae for the Dalitz plot densities have been obtained; for the integrated partial widths, exact formulae have been derived in the case where the fermions in the final state are massless [in Refs [6, 7], the fermion mass effects have not been taken into account and the totally integrated partial widths have not been derived]. The lengthy and cumbersome analytical expressions will be found in Ref. [8]. In this section, we will simply exhibit the behavior of the χ_2^0 and χ_1^+ branching ratios in the case of decays into $b\bar{b}$ and $\tau\nu$ final states, respectively [which are of more immediate interest, being in the range probed at LEP2 and the Tevatron]. They are shown in Figs. 4 and 5 for two values of $\tan\beta$ and the pseudoscalar Higgs boson mass M_A ; M_2 is fixed to $M_2 = 140$ GeV and we assumed universal gaugino masses at M_{GUT} [this leads for $\mu \sim 450$ GeV and $\tan\beta = 50$ to the set of gaugino masses: $m_{\chi_1^0} \sim 60$ GeV and $m_{\chi_2^0} \sim m_{\chi_1^+} \sim 135$ GeV; the variation with $\tan\beta$ is mild]. The trilinear couplings A_i are fixed to 100 GeV for squarks and sleptons.

In Fig. 4, $\text{BR}(\chi_2^0 \rightarrow \chi_1^0 b\bar{b})$ is shown as a function of $m_{\tilde{b}_1}$ (left) and μ (right). For large values of $\tan\beta$, the $Ab\bar{b}$ and $hb\bar{b}$ couplings are strongly enhanced, and for $M_A = 100$ GeV, the Higgs exchange contributions are largely dominant pushing the branching ratio from $\sim 20\%$ [when only the Z -boson exchange contribution is important] to values close to 90% [the remaining 10% are in general taken by the branching ratio of the decays into τ lepton pairs]. For $M_A = 500$ GeV, the Higgs exchange contribution is suppressed but for relatively small values of $m_{\tilde{b}_1}$ or large values of the parameter μ [leading again to a small $m_{\tilde{b}_1}$], $\text{BR}(\chi_2^0 \rightarrow \chi_1^0 b\bar{b})$ is still enhanced. Note that even for moderate $\tan\beta$, ~ 5 , the branching ratio can be large if M_A is small and/or μ is large.

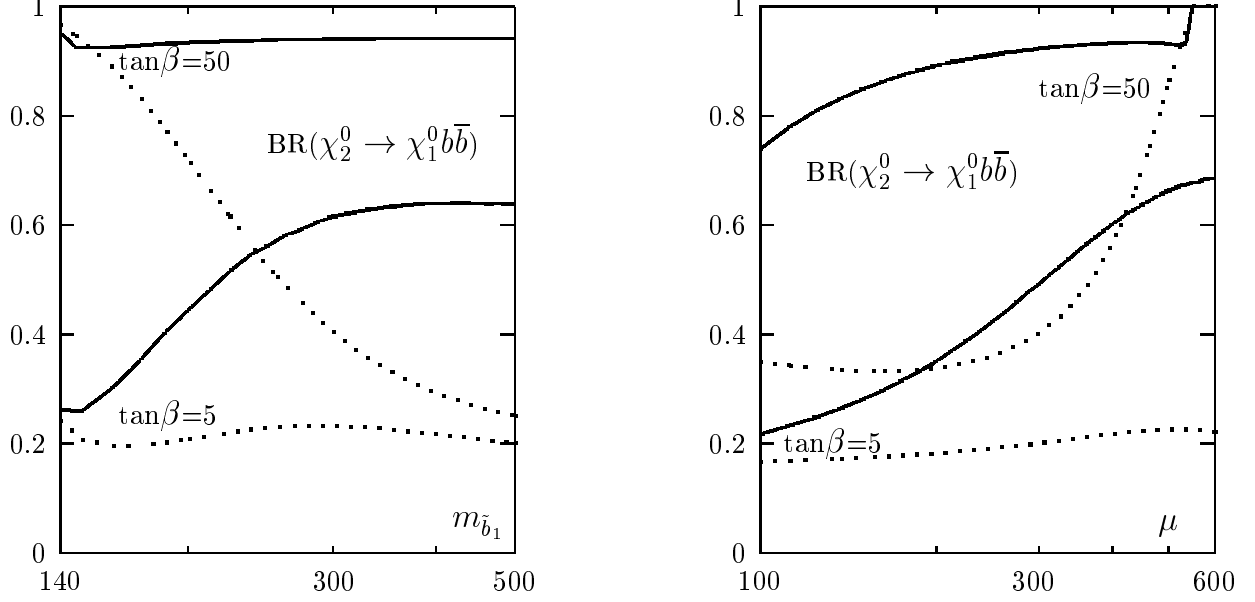


Figure 4: The branching ratio $\text{BR}(\chi_2^0 \rightarrow \chi_1^0 b \bar{b})$ as a function of $m_{\tilde{b}_1}$ for $\mu = 450$ GeV (left) and as a function of μ (right) [assuming in this case, a common scalar mass for squarks and sleptons, $\tilde{m} = 380$ GeV] for two values of $\tan\beta = 5, 50$ and $M_A = 100$ GeV (full lines) and 500 GeV (dotted lines); M_2 is fixed to $M_2 = 140$ GeV.

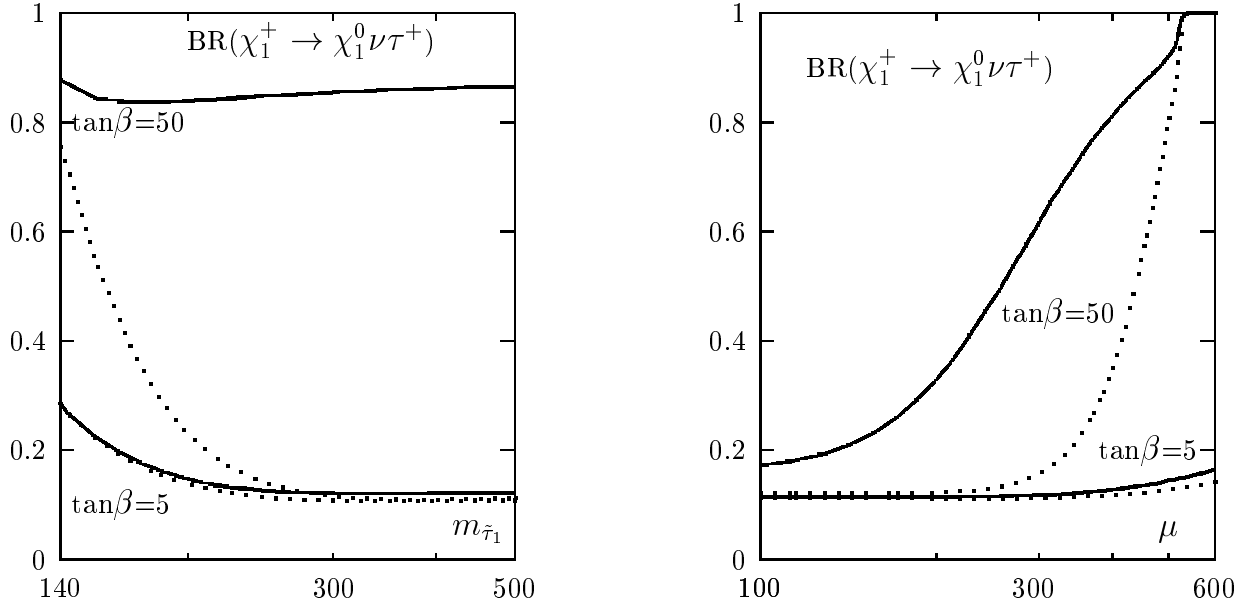


Figure 5: The branching ratio $\text{BR}(\chi_1^+ \rightarrow \chi_1^0 \nu \tau^+)$ as a function of $m_{\tilde{\tau}_1}$ for $\mu = 450$ GeV (left) and as a function of μ (right) [assuming, in this case, $\tilde{m}_q = 400$ GeV and $\tilde{m}_l = 250$ GeV] for two values of $\tan\beta = 5, 50$ and $M_A = 100$ GeV (full lines) and 500 GeV (dotted lines); M_2 is fixed to $M_2 = 140$ GeV.

Fig. 5 displays the branching ratio for the lightest chargino decay $\chi_1^+ \rightarrow \chi_1^0 \tau^+ \nu_\tau$ as a function of $m_{\tilde{\tau}_1}$ (left) and μ (right). The figure shows the same pattern as for the previous decay: for large values of $\tan \beta$, a relatively light charged Higgs contribution can strongly enhance $\text{BR}(\chi_1^+ \rightarrow \chi_1^0 \tau^+ \nu_\tau)$, but even with a heavier H^\pm boson, the branching ratio can exceed the level of 80% because of a lighter $\tilde{\tau}_1$ eigenstate.

We have developed a fortran code called **SDECAY** [11] which calculates the partial decay widths and branching ratios of the chargino, neutralino and gluino decays discussed in this note⁴. For the supersymmetric spectrum [including the renormalisation group equations for parameter evolution] and for the parameterization of the Higgs sector, it has been interfaced with the programs **SUSPECT** [13] and **HDECAY** [14]. We have compared our results with those of Ref. [6] which have been implemented in the program **ISAJET** [15]. For massless fermions, the agreement was perfect⁵, giving a great confidence that this rather involved calculation is correct.

4. Conclusions

In this note, we have analyzed the three-body decay modes of gluinos, squarks and those of the lightest charginos and next-to-lightest neutralinos in the MSSM. We have made a complete calculation of the decay widths and branching ratios, taking into account all possible channels, the mixing in the sfermion sector and the finite masses of the final particles, and provided a fortran code for the numerical evaluation of the branching ratios.

For large values of $\tan \beta$, the bottom and tau Yukawa couplings become large, leading to smaller masses of the tau slepton and bottom squark compared to their first and second generation partners. This leads to enhanced branching ratios of gluinos into $b\bar{b}$ final states and to the possibility that squarks decay into lighter sbottoms through gluino exchange can have sizeable branching fractions; this is particularly the case in scenarios where the soft SUSY breaking gaugino mass parameters are not unified at the Grand Unification scale. The branching ratios of the decays of the lightest chargino into $\tau\nu$ final states and of the next-to-lightest neutralinos into $b\bar{b}$ and $\tau^+\tau^-$ pairs are also enhanced in the large $\tan \beta$ scenario, with an additional increase being due to the stronger Yukawa couplings to charged and neutral Higgs bosons, respectively.

Thus, SUSY events will contain more b -quarks and τ leptons in the final state than initially expected. This renders the search for SUSY particles and the measurement of the SUSY parameters, where the electron and muon channels were used, less straightforward as already discussed in Ref. [17]. b -tagging and the identification of the decays of the tau leptons become then a crucial issue in the search and the study of the properties of these particles, in particular at hadron colliders such as the Tevatron and LHC.

⁴The program contains, in addition, the branching ratios for the four-body decay modes [which account also for the three-body decays] of the lightest top squark [12].

⁵The comparison was slightly tricky since the evolution of the couplings and the soft SUSY-breaking terms as well as the parameterization of the Higgs sectors are given in different approximations in the programs **SUSPECT** and **ISAJET** and we needed to use the same input parameters at low energy in both programs. We thank Laurent Duflot from ALEPH for his help with this comparison. An independent check in the case of the chargino decays, has also been performed by F. Boudjema and V. Lafage [16].

Acknowledgments: This work is supported in part by the GDR–Supersymétrie. We thank the members of the GDR, in particular Fawzi Boudjema, Daniel Denegri, Laurent Duflot, Jean–Francois Grivaz, Stavros Katsanevas, Jean-Loic Kneur, Vincent Lafage and Gilbert Moutaka for discussions.

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